



## NEW PERSPECTIVES IN PULMONOLOGY

# Long-term oxygen therapy (LTOT) revisited: In defense of traditional LTOT systems<sup>☆</sup>

## Oxigenoterapia de longa duração (OLD) revista: Em defesa dos sistemas tradicionais de OLD

In the last two decennia the stationary oxygen concentrator has been the most cost effective oxygen source for most patients using long-term oxygen therapy (LTOT).<sup>1</sup> In most countries the oxygen concentrator has, therefore, largely replaced stationary oxygen cylinders with a volume of 10 litres or more.<sup>2</sup> The oxygen concentrator is very convenient and safe for home use. However, for patients needing an oxygen flow rate of > 3 L/min the oxygen concentration delivered may be insufficient to meet the patient's oxygenation needs.<sup>3</sup>

At present, stationary oxygen cylinders are only being used as a back up for the oxygen concentrator in case of power failure or in the rare circumstance that there is no electrical power. Small oxygen cylinders for ambulatory use are, however, still being used to a great extent. They are made of aluminium, composite or steel. Their capacity is determined by their volume and pressurization, which may go up to 200 bars in steel cylinders. Their capacity remains, nonetheless, small and decreases even further with less weight. To increase their capacity they may be supplied with a demand oxygen delivery system (DODS), but the clinical performance of these devices is highly variable and may contribute to limitations in exercise tolerance.<sup>4</sup>

For patients who are still active the liquid oxygen system may be a better alternative. This system is not only reliable and very convenient for both home and ambulatory use but it also provides high oxygen purity, irrespective of the oxygen flow rate used.<sup>5</sup> With a continuous flow rate of 1 L/min patients may stay away from home for a whole day. Even patients with a continuous flow rate of 3 L/min may stay away from the stationary canister for as long as 10 h if they use two portable canisters. If combined with an oxygen conserving device, such as a transtracheal catheter or a DODS, this may even double. In order to reduce the full weight of

the portable canister (2.2–6.0 kg for a volume of 1.0–2.0 L of liquid oxygen) smaller canisters with an integrated DODS have been developed. As with small oxygen cylinders and a DODS it is, however, questionable if the maximum setting on the portable containers is able to meet the patient's oxygenation needs. A major disadvantage of all liquid oxygen systems is the requirement for pressure relief venting. The effect is that oxygen is consumed even if the patient does not use it. Another drawback is that the different systems are incompatible with each other. For out-of-town travel, this factor takes on a particular significance. Finally, the high costs of the liquid oxygen system in comparison to an oxygen concentrator may explain why at present this convenient oxygen source is provided less often than 10 years ago.<sup>6</sup>

By far the majority of patients using LTOT suffer from COPD, and most of them spend most of their time in and around their house. They are generally at rest but occasionally they may perform some light activities. These patients usually can be oxygenated effectively most of the day by an oxygen concentrator. For patients who cannot be oxygenated sufficiently with an oxygen concentrator, a liquid oxygen system seems justified. Only patients who are still active, and who desire and are able to leave their home would need a portable oxygen source. For most of them an oxygen cylinder with a capacity of 3–6 h at a continuous flow rate of 1.0–2.0 L/min would suffice to visit a friend or to do some shopping, at least in Europe where travelling time is usually not very long. The patient needing an oxygen flow rate > 2.0 L/min and who wants to leave her/his house several times per week for more than 3 h could be enabled to use oxygen nearly all the time by means of a liquid oxygen system, particularly if combined with an oxygen conserving device.

With the development of non-delivery LTOT technology patients were given unlimited access to portable oxygen.<sup>7</sup> First, special concentrators were developed that are able to safely refill reusable gaseous cylinders or liquid oxygen

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canisters in several hours at home. However, as patients still remained dependent on their home stationary unit, two types of portable oxygen concentrators (POCs) were created. One type can deliver oxygen only in the pulse-dose-mode, while the other is capable of delivering oxygen in either the continuous-flow (0.5–3.0 L/min) or pulse-dose mode. The latter type weighs, however, 7.7 kg and, unlike pulse-dose-mode only types (2.7–4.5 kg), cannot be carried in a shoulder bag. This new technology gives LTOT patients more freedom than ever, since they are no longer dependent on oxygen providers for frequent deliveries to refill or replace depleted oxygen sources.

While the new non-delivery technology may certainly have its benefits, there are several drawbacks, which may hamper the widespread use of this technology, particularly in Europe. First, due to the low weight of the POCs the oxygen production capacity is limited to no more than 1.0 L/min. Higher flow rates can only be achieved in the pulse-dose mode. However, while usually preserving adequate oxygenation at rest, POCs like DODS may not always be able to prevent serious desaturation if the respiratory rate increases, as may occur during increased activity, during an exacerbation or in an aeroplane.<sup>4,8,9</sup> This may be caused by the decrease of the ratio of oxygen from the POC to entrained air, thus decreasing the relative inspiratory oxygen fraction. Second, although the pulse-mode may be acceptable during exercise, several patients do not like it at rest or during sleep. Besides the risk of non-compliance this also raises important questions about the effectiveness of providing oxygen continuously. Third, the batteries are quite heavy, the battery life (1–8 h) may still prevent a wide range of action, especially at higher flow settings, and in case of malfunctioning or power failure there is no back-up. Fourth, there is a lack of standardization and the settings on the control panel of each POC do not specifically reflect the actual bolus size in mL. It is, however, the volume of the pulse dose and not the pulse dose setting that determines the actual delivered oxygen dose to the patient (in L/min or mL per breath). This underlines the importance of a titration study, and not only whenever a patient is set up on a POC. Subsequent reassessments, also during and following acute exacerbations, remain necessary to ensure that the selected pulse-dose settings remain effective.<sup>9,10</sup> In many European countries, however, oxygen is still not regarded as a medicine needing a proper dose. Oxygen titration is neither reimbursed nor performed much, and usually only at rest. The potential for serious under-treatment is thus real. Indeed, the benefits reported from the use of LTOT are observed only with the effective and prolonged correction of hypoxemia.<sup>11</sup> Finally, unlike the US with its long distances and desire for mobility, for most patients in Europe this technology seems unnecessary. Likewise, OCDs have never become popular in Europe. Without any incentive for the

prescribing physician, without clear overall cost effectiveness for most patients and with the low and flat price oxygen providers receive nowadays, many if not most LTOT patients in Europe will probably keep their traditional LTOT systems.

In conclusion, although non-delivery LTOT technology seems to offer more freedom than the traditional LTOT systems there is a serious risk of insufficient oxygenation, which may reduce or even annul the goal of LTOT itself: to improve survival and the quality of life by assuring adequate oxygenation at all times. Only if there were proof that this technology is able to meet this goal of LTOT, in the home setting under conditions of real life, could it be prescribed for selected patients. Until then, further research is needed to demonstrate that the same endpoints can be attained using pulse-dose-only delivery devices, like OCDs, as with the traditional LTOT systems.

## References

1. Andersson A, Ström K, Brodin H, et al. Domiciliary liquid oxygen versus concentrator treatment in chronic hypoxaemia: a cost-utility analysis. *Eur Respir J.* 1998;12:1284-9.
2. Keller RR. Long-term oxygen therapy: advances and perspectives in technical devices. *Monaldi Arch Chest Dis.* 1999;54:75-8.
3. Sautegeau A, Dautzenberg B, Moulieras J, Billard B, Preville D. (Sous-commission technique Antadir). Home controls of a sample of 2,414 oxygen concentrators. *Eur Respir J.* 1991;4:227-31.
4. Palwai A, Skowronski M, Coreno A, Drummond J, McFadden Jr ER. Critical comparisons of the clinical performance of oxygen-conserving devices. *Am J Respir Crit Care Med.* 2010;181:1061-71.
5. Kampelmacher MJ, Kesteren van RG, Deenstra M, Douze JMC, Lammers J-WJ. Long-term oxygen therapy. *Neth J Med.* 1994;44:141-52.
6. McCoy RW. New technologies for lighter portable oxygen systems. *Respir Care.* 2002;47:879-81.
7. Dunne PJ. The clinical impact of new long-term oxygen therapy technology. *Respir Care.* 2009;54:1100-11.
8. Chatburn RL, Williams TJ. Performance comparison of 4 portable oxygen concentrators. *Respir Care.* 2010;55:433-42.
9. Gallegos LC, Shigeoka JW. Novel oxygen-concentrator-based equipment: take a test drive first! *Respir Care.* 2006;51:25-8.
10. AARC Clinical Practice Guideline. Oxygen therapy in the home or alternate site health care facility – 2007 revision & update. *Respir Care.* 2007;52:1063-8.
11. Nocturnal Oxygen Therapy Trial Group. Continuous or nocturnal oxygen therapy in hypoxemic chronic obstructive lung disease: a clinical trial. *Ann Intern Med.* 1980;93:391-8.

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